

Willingness to Pay for Water in the West as Indicated
by Water Market Prices

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Cooperative Agreement RMRS-98150-RJVA
Preferences and Willingness to Pay Related to Natural Resource Management

between
Colorado State University
and
Rocky Mountain Research Station

Thomas C. Brown
Rocky Mountain Research Station
USDA Forest Service
Fort Collins, Colorado

and

John Loomis
Department of Agricultural and Resource Economics
Colorado State University

with the assistance of
Alexander Bujak
Research Assistant
Department of Agricultural and Resource Economics
Colorado State University

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Scarcity begets trade, which begets markets. As population and economic growth in the West have increased demand for water, it has become scarcer. Where institutions allowed it and transaction costs were not excessive, that growing scarcity often brought willing buyers and sellers together in what is called a water market. The term “water market” lacks a precise definition, but once a few voluntary trades of water of common physical and legal characteristics occur, it is said that a water market has developed. For example, when shares of an irrigation company—which all carry the same physical and legal descriptions (such as amount of water per share, timing of availability, and water quality)—are actively exchanged at freely agreed-upon prices, a water market is said to exist.

In many dry parts of the West water scarcity is not a recent development, but water markets nevertheless often failed to, or were slow to, materialize because of institutional constraints or a lack of experience with market trades. The dearth of water market data led economists to develop or adapt several methods for estimating the marginal value of water. Those methods were applied in a large number of published studies (see the summary by Gibbons, 1986).¹ While the methods are still useful, and indeed are essential where water markets have failed to develop, the appearance of water markets in other locations has lessened the need to rely on the valuation methods because, ideally, such markets yield the very prices that the methods were designed to estimate. Thus, with the existence of markets, the complicated and time consuming application of valuation methods has been replaced by mere observation of prices. The voluntary actions of buyers and sellers naturally yield prices that indicate the marginal value of water.

This of course sounds too good to be true, and it is. Market imperfections and government subsidies commonly affect the price of water and therefore its accuracy in indicating marginal value. And in many areas where water trades occur they occur so seldom that it is difficult to assess the reliability of the prices that result. Indeed, many gradations of water market are found, from the most rudimentary of markets to the very well functioning. Nevertheless, water markets offer a wealth of information about the value of water, and enough trades have now occurred that a summary of the values revealed by the trades is in order.

Three things are essential for a water market to exist. First, there must be a well-administered system of transferable water rights. As is well known, the doctrine of prior appropriation that underlies water law across the West allows for clearly defined and transferable water rights,² and state agencies or the courts administer and enforce those rights, although the states differ in how they implement the doctrine and administer the

¹ The methods have been summarized by Wollman (1962), Young and Gray (1972), the U.S. Water Resources Council (1983), Gibbons (1986), and Young (1996), among others.

² An early but still very good discussion of water marketing in the context of the prior appropriation doctrine is found in chapter 9 of the book by Hirshleifer et al. (1960).

water rights systems (Gillilan & Brown, 1997; National Research Council, 1992).³ Second, the water must be mobile, both legally and physically. Legal mobility follows from the prior appropriation doctrine, which specifies that water is separable from the land where the water might be used. Physical mobility is generally facilitated by a system of diversion structures, canals and pipes, plus perhaps storage reservoirs, for moving the water from the seller's location to the buyer's. Third, the transaction costs of transfers must be low enough to make entering into a transaction sensible. Transaction costs are the costs incurred to bring about the transaction, such as legal and broker fees.⁴ Markets of course differ in the degree of physical mobility that they offer and in the transaction costs of transfers.

In addition to those three essential features, water markets are facilitated by conditions such as: (1) readily available information about quantities, prices, and trading opportunities, (2) the presence of many buyers and sellers,⁵ (3) a homogeneous water product, and (4) a lack of return flow issues.⁶ Markets differ greatly in the extent to which these conditions are present. We will return in more detail to these issues, but for now we focus on what water markets have to offer.

Studies of water markets have typically consisted of a detailed examination of one or a few specific markets (e.g., Hartman & Seastone, 1970; Howe & Goemans, 2003; Michelsen, 1994; Saliba, Bush, & Martin, 1987). Only with a detailed examination can the numerous characteristics of the individual markets be given their due consideration.

³ A water right under the prior appropriation doctrine specifies an amount of water that may be diverted (or otherwise used) and a priority for the diversion relative to the priorities of other rights on the river. A junior's use may be curtailed if it would interfere with the senior right receiving its full allotment. However, in some cases—such as where water users have banded together in a mutual water company (commonly called a ditch company)—each owner has a certain fraction of the group's total water supply, and no distinction is made among owners regarding priority. In this case, as the total supply changes with the weather from one year to the next, the amount going to each user also changes—all users share the burden of dry times and the bounty of wet times.

⁴ From the standpoint of buyers and sellers, transaction costs include those involved in learning about available supplies or potential demands and finding a willing seller or buyer (which may involve a broker fee), establishing the precise nature of the water right or lease at hand (which may involve legal, engineering, and hydrologist fees plus the cost of title searches), negotiating a deal (which may again involve the services of experts), obtaining approval from the relevant state agency or court (which may involve filing or court fees plus the services of experts), and the cost of moving the water to the buyer's location, if any. For large transfers that might raise environmental concerns or legal challenges (such as those pursuant to the Endangered Species Act), transaction costs can be substantial [Carey, 2002 #515; Colby, 1990 #514; Howe, 1990 #513].

⁵ The number of buyers and sellers is likely to increase the larger is the area connected by the water distribution infrastructure and the greater is the amount of water available to that infrastructure.

⁶ Under the prior appropriation doctrine, a water transfer may not injure the other water right holders, even if their rights are junior to the right being transferred. Thus, a water transfer may not alter the return flow of the subject right if that return flow was used by other right holders downstream. So, for example, if a transfer would move the water to another drainage basin, that transfer must be restricted to the consumptive use portion, leaving the return flow portion in the original stream. Quantifying the return flow portion can be complex and costly. Importantly, some water transfers are not subject to return flow concerns. For example, the rules for CBT (Colorado Big Thompson project) shares specify that the full water allotment may be transferred (Hartman & Seastone, 1970; Michelsen, 1994). This rule was possible because the CBT project apportions water from another basin—water that was new to the South Platte basin when it was first introduced and the rules for transfers were set.

This study, to the contrary, takes a broad look across the western U.S., emphasizing geographical scope rather than in-depth focus. This “big picture” approach offers a look at how prices in general have changed over the past few years and at how they differ across locations or across the purposes for which the water was purchased.

When water is sold in the West, either a water right changes hands or use of the right is leased for one or more years. A water right conveys access to a specified quantity of water in perpetuity, subject to particulars such as priority, timing, and location. When water is leased, the holder of the right agrees to deliver, or allow the buyer access to, a certain quantity of water for a stated time period, subject to conditions such as timing of access and location. This report focuses on both of these types of transactions.

Methods

The broad-scale examination of water prices reported here is only possible because of the *Water Strategist* and the *Water Intelligence Monthly*, which have summarized many of the available Western water market transactions in reports released on a monthly or quarterly basis.⁷ The transactions reported by these publications for 1990-2002 were tabulated to provide the estimates of the price of water described herein.⁸

Each water transaction entry in the *Water Strategist* or *Water Intelligence Monthly* briefly summarizes one or more actual trades.⁹ The entries do not allow a full understanding of what influenced the price, and thus do not aid greatly in understanding why prices differ from one location to another.¹⁰ Further, the entries are not always consistent in how the transactions are described (perhaps because some information was not available or because the diligence of the personnel compiling the entries varied).

⁷ Published by Stratecon, Inc., P.O. Box 963, Claremont, California 91711. The transactions summarized here were taken from the *Water Intelligence Monthly* for 1990-1994 and from the *Water Strategist* for 1995-2002. The *Water Strategist* reports used here were published more or less quarterly in 1995-1998, and monthly beginning in 1999. A different publication, the *Water Market Update* published by Shupe and Associates, Inc., summarized transactions for three years prior to 1990.

⁸ These publications do not report on all Western water market transfers. Two examples should suffice to demonstrate this. First, cities along the Colorado Front Range regularly sell surplus water to farmers and others on a temporary basis. The city of Fort Collins, for instance, leased rights to 24,561 acre-feet in 2002 (at an average of \$18.85 per acre-foot) and similar quantities in other years (Fort Collins Utilities, 2000). These leases were not reported in the publications. Second, Howe and Goemans (2003) report, based on their examination of water court records for Colorado Division 1, that in 1992 about 230,000 acre-feet of non-CBT water rights changed hands in the South Platte Basin, whereas the *Water Intelligence Monthly* lists non-CBT water rights trades for that year and basin totaling fewer than 4500 acre-feet. This may be an unusually large discrepancy, but in any case because water trades are rarely publicized, it is not unlikely that many trades have been missed by the *Water Intelligence Monthly* and the *Water Strategist*. Thus, the current report must be viewed as indicating the nature, but not the breadth, of Western water trades.

⁹ An “entry” as used here is a single write-up in the *Water Strategist* or *Water Intelligence Monthly*, which may report on one or more transactions. A “case” indicates a case of analysis for the current study, which originated as all or part of an entry. “Trade” and “transaction” are used interchangeably herein to indicate any exchange involving water, whether an exchange of water for water or of water for money. “Purchase” and “sale” are used interchangeably to indicate the exchange of water for money.

¹⁰ For example, the buyer may be labeled as “a farmer” or “a developer” without any indication of the buyer’s location, even though the water at issue could have been delivered over a very large area containing several distinct water markets.

Nevertheless, most of the entries do provide sufficient information for a rudimentary analysis of the factors influencing water market prices.

The entries typically included buyer, seller, purpose for which the water was purchased, type of transaction (whether purchase or lease of a water right), and the source of the water (surface water, ground water, effluent, or treated water). Buyers and sellers were categorized herein as one of the following: (1) municipality, (2) farmer (irrigator), (3) private environmental protection entity (e.g., public trust concern, private entity such as the Nature Conservancy), (4) private water entity providing water to many users, such as a water “district,” “association,” or “company,” herein labeled a “water district,” (5) public agency (federal or state government agency, conservancy district, or other water “authority”), (6) power company (thermoelectric energy), (7) mining company, (8) real estate developer, (9) other entity (e.g., investor, country club, business such as feedlot, individual homeowner, or (10) several entities (several buyers or sellers of different types, such that the transaction could not be neatly assigned to one of the other categories¹¹).

The purpose of the transaction was characterized herein as one of the following: (1) municipal or domestic (including commercial and industrial if serviced by a municipality, and golf courses and other landscape irrigation), (2) agricultural irrigation, (3) environmental (e.g., instream flow augmentation), (4) thermoelectric cooling, (5) recreation, (6) mining, (7) aquifer recharge, (8) other (e.g., augmentation of flows leaving the state per court order, supply to individual businesses such as feedlot or manufacturing plant, an investment of undefined characteristics, unspecified), or (9) several (several purposes, such that the transaction could not be neatly assigned to one of the other categories).

Some entries covered several related transactions. For example, several sellers or several buyers, or both, may have been included in the entry. Or several transactions within the same market may have been listed together in the same entry. Such entries were broken down into separate cases for analysis if the following two conditions were met: distinct prices were listed, and different categories of buyers, sellers, or purposes were involved.¹² After this disaggregation process, a total of 2247 transactions were available for the 1990-2002 period.

The Colorado Big Thompson (CBT) market is the single most active water market in the West, with up to 30 or more purchases per quarter by municipalities alone.¹³ It is also a market about which market information is readily available. The entries listed 881 CBT trades over the 13 years. Because the sale price for CBT shares differed little among trades completed during a given month, and because the volumes traded were typically small (averaging about 40 acre-feet), all CBT transactions of a single purpose within a given month were tabulated as one case for analysis in order to avoid having CBT transactions overwhelm the summary statistics. This aggregation process left a total

¹¹ For example, the entry may report that “a corporation and a municipality have acquired ...”.

¹² Often in such cases the number of units of water for each separate trade were not listed. In such cases, it was assumed that the total number of units was distributed equally among the different trades.

¹³ The CBT project is managed by the Northern Colorado Water Conservancy District. Its delivery area is located generally north of Denver and largely in climate division 4.

of 202 CBT cases for the 13-year period, and thus a total of 1568 cases (2247–679) for analysis.

Of these cases, 316 were omitted from further analysis because key information was missing (such as price or amount of water transferred), something other than raw water (i.e., effluent or treated water) was involved, or the price listed did not appear to be a good indication of the value of raw water.¹⁴ Thus, 1252 qualifying cases (1568–316) were left for analysis. Figure 1 shows the number of qualifying cases by climate division of the buyer for the 14 western states; two additional states (Nebraska and North Dakota) had entries without useable price data.¹⁵

Prices, expressed on a per acre-foot basis, were adjusted to year 2002 dollars using the consumer price index; and prices for water rights were converted to an annual basis using a 3 percent interest rate, which is approximately the annual growth rate in real gross domestic product over the past 20 years in the U.S. Although mean prices are also reported, this analysis emphasizes median prices, which more accurately indicate the price of a typical water sale when the price distributions are skewed. As will be seen, the price distributions are highly skewed, causing the means to be heavily influenced by a few highly priced transactions.

Prices paid for untreated water often include reimbursement for water management—including such services as storage, conveyance, and general administration—in addition to the cost of the raw water. Because our primary interest is in water value, costs of water management would ideally be removed from the price data. However, it is often very difficult to separate the value of these services from the value of the raw water in the stream. In fact, storage and delivery services are so commonly part of water transactions that such services were often not even mentioned in the entries. Because any effort to remove the value of these services from the prices would be incomplete as well as inconsistent across trades, no such effort has been made. Most prices reported here include the value of such services. And, to fully capture the prices paid for those services, the listed here prices include the annual assessment fees charged to share holders to help pay for those services (where that information was reported in the entries). Thus, the prices reflect what the water rights holders and lessees have agreed to pay for their water and any delivery services that are attached to the water.

Results

Three climatic divisions have over 75 qualifying cases (Figure 1). Division 4 in northeast Colorado, including Denver, Fort Collins, and other cities along the northern

¹⁴ Eighty transactions were omitted because goods of substantial value besides raw water—such as land or water distribution systems—were included in the transaction and captured in the price. In addition, 28 transactions were omitted because they involved water exchanges (trades of water for water, some of which also included a cash component). Another 67 were omitted because they were of effluent, and five were omitted because they involved water treated to potable standards. Finally, an additional 18 cases were omitted because a water volume was not listed and an additional 118 transactions were omitted because a price was not listed or the price listed (usually \$0) did not appear to represent a market transaction.

¹⁵ Climate divisions are available at: www.cdc.noaa.gov. In Texas all 29 transactions along the Rio Grande that could not accurately be assigned to a climate division were assigned to division 6, which otherwise would have received no entries.

Front Range, has 336 cases, 202 of which are CBT cases.¹⁶ Division 5 in California, capturing the southern (San Joaquin River) portion of the Central Valley and on down to the Bakersfield area, has 111 cases, 63 of which involve Central Valley Project water and another 40 of which involve State Water Project water.¹⁷ Division 10 at the southern tip of Texas, along the Rio Grande as it enters the Gulf, has 98 cases, nearly all of which involve water from the Rio Grande. Nine climatic divisions had between 26 and 75 cases—three in California, two in Texas, and one each in Colorado, Nevada, and New Mexico (Figure 1). Thirteen climatic divisions had between 11 and 25 cases, and 41 had 10 or fewer cases. Seventy-four climatic divisions in the 14 states (all states in Figure 1 except North Dakota, South Dakota, and Nebraska) had now cases.

As we begin this extensive summary of western water market transactions, it bears repeating that we are dealing only with those transactions reported by the two aforementioned publications. Although we have much data—data sufficient, for example, to show trends in price for specific kinds of water use—these results are not necessarily definitive because some transactions were missed and we have no way to know whether the missed transactions are randomly distributed across the population of transactions. This analysis is most valuable in characterizing the nature of western water market trades, not the full extent of those trades.

Quantity of Water Sold

The median amount of water transferred per case is 911 acre-feet for the full set of 1568 cases and 741 acre-feet for the 1252 cases meeting the criteria for further analysis (the means are 17,350 and 18,017, respectively).

Figure 2 shows the trend in total water volume transferred for these two sets of cases. The water volume traded has varied widely over the past 13 years and shows no consistent trend.¹⁸ Most interesting is the difference in amount of water transferred in leases versus rights (Figure 3). At least three findings of interest are apparent in the figure. First, in all years much more water has been transferred via leases than via rights, which probably reflects that fact that large amounts of water are easier to agree about on a temporary than on a permanent basis. The median lease size over the 13 years is 5925 acre-feet per case, compared with a median size of water rights transactions of 110 acre-feet per case.¹⁹ This dramatic difference has been maintained during each of the 13 years, as suggested by the fact that the median lease size in any individual year has never dropped below about 3000 acre-feet per case, whereas the median water right sale size has always been below 250 acre-feet per case. Second, there is considerable annual variation for both types of transactions in amount of water transferred, and no apparent

¹⁶ The next most common markets in Colorado Division 4 are North Poudre Irrigation Company with 24 cases and Windsor Reservoir and Canal Company with 11 cases.

¹⁷ Moore and Howitt (1988) provide a nice discussion of water management in the Central Valley.

¹⁸ The larger than usual difference in 2002 between the volume for all cases and that for qualifying cases is due mainly to a large (579,200 acre-feet) donation in Oregon from an electric power firm resulting from the decommissioning of a hydroelectric dam. The donation was dedicated to maintaining instream flows on the river.

¹⁹ The aggregation of CBT transactions, described above, elevated this median. Sales of CBT shares have averaged about 40 acre-feet, such that if all the individual CBT sales were included in the computation of the median, it would be much below 110 acre-feet.

relation between the two types of transactions. Third, there is no obvious trend in volume transferred for either type of transaction.

Ten percent (121) of the qualifying cases involve ground water, with the remainder (1131) being of surface water. However, only 4% of the water transferred in these trades has been ground water, as suggested by the fact that the average water volumes per qualifying case are 7131 acre-feet for ground water and 19,181 for surface water. Eighty-three percent of the ground water volume and 96% of the surface water volume traded via leases (with the remainder trading via water rights sales).

Occurrence and Price of Qualifying Cases Aggregated Over All 13 Years

Table 1 summarizes cases by state for the 14 western states with qualifying cases (i.e., sales that contained useable market prices for raw water). A quick look at the table reveals at least four findings of interest. First, mean prices exceed median prices, indicating a skewed distribution. This holds true for the complete set of cases (a mean of \$97 per acre-foot per year, versus a median of \$59, Figure 4) and for all but two states. Second, the range of prices per acre-foot is substantial for each state, with minimums close to \$0 and maximums typically in the \$100s. Clearly, water changes hands at a variety of prices (depending, as seen below, on various site-specific characteristics). Third, water trades are much more common in some states (e.g., California and Colorado) than others (e.g., Montana and Oklahoma). Water scarcity no doubt plays some role in determining the number of trades that occur in a state, but institutional and legal differences are probably the most important factors affecting sale frequency among the Western states, all of which have areas of little precipitation. Fourth, the median prices vary substantially among the states, ranging from \$7 in Idaho to over \$100 in Nevada.²⁰ Further, there is no apparent relation between number of trades and median price.

In terms of median price, and ignoring the two states with fewer than 10 cases, the states fall into four groups. Colorado and Nevada make up the high-price group, with median prices above \$90 per acre-foot per year. The next group—consisting of Arizona, California, Kansas, New Mexico, and Wyoming—has median prices ranging from \$40 to \$67. The third group—Texas and Washington—has a median price of about \$30. Finally, Idaho, Oregon, and Utah fall in the low-price group, with median prices below \$20.

To begin to understand the reasons for the range of median prices, consider Table 2, which summarizes the sales by type of transaction, either a lease or a perpetual right. As seen in the table, the median price for rights (\$83 per acre-foot per year) is nearly twice that for leases (\$45) given the 3% interest rate for annualizing prices of rights.²¹ Fifty-one percent (639) of the sales were leases (though the percentage depends on how CBT sales were summarized, as mentioned above).

²⁰ Medians for Montana and Oklahoma are based on so few observations as to be unreliable. Data on these two states are included in the tables and general summaries but are not given specific attention in the text.

²¹ An interest rate of 1.45% is necessary to reduce the median water price of water rights to that for leases of \$45 per acre-foot per year.

Table 3 shows the state breakdown in median price by type of transaction. Of interest here is that, contrary to the overall picture of Table 2, the median price of leases exceeds that of rights in most states. The superiority of median water rights prices in Table 2 results largely from the fact that 57% of the water rights cases (347) are for Colorado, a state where the median price of water rights far exceeded the median price of leases. Fully 201 (58%) of the 347 water rights cases for Colorado are of CBT shares, and another 134 (39%) are for other ditch company shares along the northern Front Range within or near the area of the Northern Colorado Water Conservancy District where CBT shares trade (i.e., in climate division 4, Figure 1). Also of interest is that for 10 of the 14 states the number sales of leases exceeded the number of sales of rights. The exceptionally high number of water rights transactions in Colorado reflects the relative ease with which such transactions can be consummated and the strong demand for secure water supplies by the fast-growing Front Range cities.

Table 4 summarizes the cases by the purpose for which the water was purchased. Over half (665) of the cases are for municipal purposes, another 24% (304) are for irrigation, and 10% (128) are for environmental purposes. The highest prices (a median of \$172) were paid for mining; all 26 of these transactions were leases, 23 of which occurred in Texas. The median price paid for municipal uses (\$88) was nearly three times that paid for irrigation water (\$30) and over twice that paid for environmental purposes (\$37). The lowest prices were paid for recreation and thermoelectric cooling. As Table 5 shows, purchases for municipal purposes tended to be of water rights, suggesting that municipalities desire—and are able to pay for—dependability of supply. Purchases for environmental or mining purposes tended to be of leases. Purchases for irrigation purposes were divided 60/40 between leases and rights.

Figures 5-7 show the very skewed distributions of municipal, irrigation, and environmental water prices. The distributions for municipal and irrigation uses are bimodal. The upper mode of the municipal distribution centers on the \$100 to \$120 per acre-foot category, which includes 87 cases, 50 of which are from Colorado (most of these are CBT sales) and another 21 of which are from Nevada (largely in the Truckee River area near Reno). The upper mode of the irrigation distribution centers on the \$80 to \$120 per acre-foot category, which includes 41 cases, 34 of which are from Colorado (most of these are CBT sales).

Among the qualifying cases, transfers for municipal purposes occurred in all but two states (Table 6). The median price of the 665 cases for municipal purposes of \$88 per acre-foot per year is heavily influenced by sales in Colorado, where the median price of the 230 cases is \$107. All but 17 of these 230 cases occurred in climate division 4, largely along the northern Front Range. Other states with both high median prices for municipal purposes and a substantial number of cases are California (median of \$128), Nevada (\$107), and Wyoming (\$78). Excepting Colorado, the median price of the remaining 435 sales for municipal purposes was \$61.

Transfers for irrigation occurred in all but two states (Table 6). The median price of the 304 cases for irrigation water, of \$30 per acre-foot per year, is heavily influenced by Colorado, which had over one-third of these cases and a median price of \$79. Other states with a substantial number of cases include California (median of \$48), Idaho (\$7),

and Texas (\$25), indicating a great range across states. Excepting Colorado, the median price of the remaining 195 cases for irrigation purposes was \$18.

Transfers for environmental purposes occurred in ten states (Table 6). The median price of the 128 cases is \$37 per acre-foot per year. States with the highest median prices and with at least ten cases are California (median of \$60), Colorado (\$13), Idaho (\$8), Oregon (\$21), and Washington (\$31).

Who Sells to Whom, and for What Purpose?

Farmers are the sellers in 40% (502) of the qualifying cases, not counting their participation in the 197 cases involving several sellers (Table 7). Public agencies are the sellers for another 15% (194) of the cases. In California, the state with the most public agency sales (56 cases), such sales are nearly all leases and typically involve State Water Project or Central Valley Project water. In Arizona (24 cases), most public agency sales involve Central Arizona Project water managed by the Arizona State Land Department, the Central Arizona Water Conservancy District, and other agencies. In Colorado (22 cases), nearly all public agency sales are leases of water from reservoirs managed by the U.S. Bureau of Reclamation. In Oregon (17 cases), most public agency sales are leases to irrigators by the Bureau of Reclamation, with some also by the U.S. Army Corps of Engineers. In Wyoming (30 cases), all public agency sales are from reservoirs managed by the U.S. Bureau of Reclamation.

Ignoring seller types with less than 10 cases, sellers fall into two groups in terms of median price. Median prices paid in purchases from water districts and public agencies ranged from \$42 to \$47 per acre-foot per year. Median prices paid in purchases from municipalities, farmers, others, and several ranged from \$65 to \$74. Finally, a median of \$107 was paid in purchases from developers (Table 7).

Farmers tended to sell to municipalities, public agencies, or other farmers (Table 8). Public agencies and water districts sold to a mixture of buyers, most importantly municipalities, farmers, water districts, and public agencies. Developers usually sold to municipalities.

Municipalities were the most common buyers of water, accounting for 28% (350) of the cases, not counting their participation in the 15% (183) of the cases involving several buyers. Other active buyers were public agencies with 16% (206) of the cases, farmers with 16% (197) of the cases, and water districts with 12% (156) of the cases. Developers and mining companies paid the most for water, whereas farmers and environmental interests paid the least (Table 7). Prices paid by water districts and public entities tended to be lower than prices paid by municipalities.

Fifty percent of the public agency purchases were for environmental purposes, with most of the rest for municipal or irrigation purposes (Table 9). Sixty-two percent of water district purchases were for municipal purposes, with another 34% for irrigation.

In terms of water volume, 22% of the water leased was leased for municipal purposes (Table 10), whereas 69% of the water transferred via water rights purchases were for municipal purposes (Table 11). For agricultural irrigation these percentages were 23% and 8%, respectively, and for environmental purposes the percentages were

16% and 11%, respectively. Also of note is that much more water sold for multiple purposes was transferred via leases (35%) leases than via water rights (12%).

Trends in Occurrence and Price – Are Transfers Becoming More Common?

The number of cases per year (across all states and purposes) ranges from a minimum of about 77 in 1995 to a maximum of 142 in 1999 (Figure 8).²² Recent years show an increase in the number of cases (over the 13 year period, the three highest numbers of cases occurred in 1999, 2001 and 2002); the overall increasing trend is statistically significant (at the .05 probability level based on the Mann-Kendall test for time trends). Looking separately at sales of leases and rights (Figure 9) we see that the number of leases has increased substantially over the past 13 years; this increase is significant. This increase in the number of leases is evident in most states. The numbers of sales of rights show no trend.

The median price per year (across all states and purposes) ranges from \$47 in 1998 to \$85 in 1992 (Figure 8).²³ No overall trend is evident. However, looking separately at sales of leases and rights (Figure 10) we see that the median price of rights has increased substantially since 1993 (although the overall trend is not significant at the .05 level), whereas the price of leases has changed little since 1993. Looking at the three states with the most water rights cases (and with sufficient cases each year to compute meaningful annual estimates of median price), we see that Colorado is largely responsible for the recent increase (Figure 11). The dramatic increase in prices in Colorado is associated with growth along the Front Range, especially in the residential housing market. Most Front Range cities and towns require developers/builders to provide either water rights or the money to purchase such rights. The necessary amount of money is determined by the cities and towns and is updated as market conditions change. The prices charged by some cities closely track the price of CBT shares.

Figures 12-14 show trends in price and in number of cases for the three water uses with the most cases. No distinct trend is apparent in sales for municipal purposes (Figure 12). For irrigation, however, both price and number of trades have been dropping since 1992 (Figure 13). For environmental purposes, the number of trades has risen dramatically but the price shows no trend (Figure 14). The erratic behavior of median price of water sold for environmental purposes may simply reflect the low number of trades per year.

²² Some variation during 1995-1998 may be an artifact of the assignment to individual years of transactions listed in quarterly reports. In particular, the fall 1997/winter 1998 report spanned two years.

²³ In Figure 8, the unusually high median price in 1992 occurred largely because of a three-fold increase in the number of lease entries in California (mainly for municipal and irrigation purposes), where lease prices were relatively high in the early 1990s. The sales took place in various basins throughout California. The unusually high number of entries in 1999 occurred largely because of increases in leases in California, Kansas, and Texas and increases in sales of rights in Nevada and Utah. The reason for the increased number of entries is not clear; 1999 was drier than the previous year in all of these states, but 1999 was not an exceptionally dry year (for example, 2002 was drier than 1999 in all but one of the states).

Selected Markets

For most markets the number of qualifying cases is small, usually below five, but for a few there are enough cases to examine market-specific trends. As an example, Figure 15 shows median prices for water rights for five water markets along the Colorado Front Range and in eastern Colorado. Four of the markets are for shares of ditch companies and the other (CBT) is for shares of water managed by a conservancy district.

For the CBT market, the data allowed computation of a median price for each of the 13 years, based on 201 CBT water rights cases. The annual medians were based on from 13 to 19 cases each. Much less data were available for the other four markets, and none of the markets provided a measure for every year. For the North Poudre Irrigation Company there were 16 reported sales that occurred during 8 years. For the Windsor Reservoir and Canal Company there were 11 reported sales during six years. For Twin Lakes Reservoir and the Farmers' Highline Canal and Reservoir Company there were 14 sales in 9 years and 5 sales in 4 years, respectively. Note that we include here only the trades recorded by the *Water Intelligence Monthly* and *Water Strategist*; other trades may have occurred.

The CBT market reflects sales of water managed by the Northern Colorado Water Conservancy District and diverted from the Colorado River drainage to 30 cities and towns and about 600,000 acres of farmland in the South Platte drainage. Water in the CBT project is managed using 12 reservoirs, 35 miles of tunnels, and 95 miles of canals. The project is designed to deliver up to 310,000 acre-feet per year and typically delivers about 230,000 acre-feet. As seen in the figure, the price began increasing in 1995 and rose dramatically in 2000. Over half of the CBT shares are now owned by cities (Howe & Goemans, 2003).

Shares of the North Poudre Irrigation Company consist of a combination of CBT shares and native water from the Cache la Poudre River, which flows from the mountains along the Continental Divide through Fort Collins and on to its confluence with the South Platte River at Greeley. The company operates several small reservoirs, such as Fossil Creek (11,100 acre-feet of capacity) and Halligan (6,400 acre-feet of capacity). About one-third of the shares are owned by the City of Fort Collins; most of the other shares are owned by farmers north of Fort Collins. The price of North Poudre shares tends to track that of CBT shares—in part because North Poudre shares each include some CBT water—but is lower on an acre-foot basis, largely because of the market area for North Poudre shares (the area over which the water can be delivered) is much smaller than that for CBT shares, and perhaps also because the non-CBT portion of the shares cannot be used for municipal purposes without a formal change of use which must be approved by the water court.

The Windsor Reservoir and Canal Company operates Windsor Dam (20,400 acre-feet of capacity) near the city of Windsor, in Weld County on a canalized side stream of Cache la Poudre River. The price has remained relatively stable, ranging from \$29 to \$59 per acre-foot on an annual basis. The reservoir and its delivery area are relatively small, which in part accounts for the relatively low price.

The Farmers' Highline Canal and Reservoir Company, located in the South Platte drainage, serves, among other customers, fast growing cities in the northern portion of the

Denver metro area including Arvada, Westminster, and Thornton. Prices have been relatively high—typically above \$200 per acre-foot on an annual basis—reflecting the economic and population growth, the dwindling ground water supplies along this part of the Front Range, and the scarcity of surface water.

Water from Twin Lakes Reservoir (141,000 acre-feet of capacity), located along the Arkansas River a few miles south of Leadville, serves users in a variety of locations, including south Denver metro areas such as Aurora, the Colorado Springs area, along the Arkansas River as it flows through Pueblo, Colorado, and along the Upper Arkansas River such as in Leadville. Twin Lakes water is diverted from the Colorado River drainage, and thus was new to the eastern side of the continental divide when the diversion was created. Prices have been relatively high—typically above \$200 per acre-foot per year—both because of the economic and population growth and the dwindling ground water supplies along parts of the Front Range, and because of increased demand pursuant to the 1995 Supreme Court decision in *Kansas v. Colorado* that required the Upper Arkansas Water Conservancy District to augment streamflows to make up for reduced flows due to pumping along the Arkansas River in Colorado.

Two main points are evident from this comparison. First, prices vary considerably, even among markets located quite close to each other. Such markets are distinguished by local economic conditions, availability of alternative supplies (such as ground water as a supplement for surface water), extent of water distribution infrastructure, and past decisions to obtain secure surface water rights. Second, within a given market prices can change considerably over time as demand changes.

Water Market Prices as Indicators of the Value of Streamflow

As mentioned earlier, water market prices have limitations as indicators of value suitable for benefit-cost analysis or other social decision making. There are two major limitations.

First, water markets are imperfect (i.e., less than purely competitive). Causes of market imperfection include: (1) legal or administrative impediments to market entry, (2) physical constraints on water delivery, (3) customs or regulations affecting the price at which the water sells, (4) the transaction costs of selling or leasing water rights, and (5) special legal or administrative constraints on use or transfer of the water. All of these factors tend to limit the number of trades that occur, and can make the observed market price an unreliable indication of the water's social value.

The other basic limitation of water markets as sources of information about value of streamflow is that prices often reflect more than just the value of raw water in the stream. In addition to the value of raw water, a water market price often reflects the value of services such as storage and conveyance of that water.²⁴ Storage allows delivery when the water's utility is greatest. To estimate the raw water portion of the water market price, the contribution to the price of these services must be subtracted from the observed price.

²⁴ An additional consideration is that the price may be affected by expected future increases in the demand for that water (i.e., speculation). Opinions differ on whether speculation interferes with the establishment of a market price that indicates social value.

In addition to these two limitations, it must be realized that active water markets exist in relatively few locations, and transferring a value from one location to another is risky because water market prices reflect the particular physical and legal characteristics of the market in which they occur. These characteristics include: (1) the timing of the availability of the water (e.g., a right that allows delivery anytime during the year will be more valuable than a right restricting delivery to only a few months), (2) the security with which the water can be delivered, which is related to the average and minimum (firm) annual yield of the right, which is in turn affected by the priority of the raw water relative to other rights on the river, (3) the extent of the market (i.e., the number of buyers and sellers in the market, which reflects the size of the geographic area over which the water can be transferred), (4) the quality of the water, (5) the type of use to which the water may be put (e.g., municipal users can typically afford to pay more than farmers), and (6) costs of moving the water to the new location. Because these factors differ from one market to the next, water market prices are typically not directly comparable (thus complicating the process of benefits transfer).

Key Findings

1. The incidence of water market trades is geographically variable. Markets are very active in a few areas of the West, but most areas have had few trades over the past 13 years. Although three states (California, Colorado, and Texas) account for two-thirds of the qualifying sales, even in these states some areas have had very few trades.
2. In a given year, roughly ten times more water changes hands via leases as changes hands via sales of water rights.
3. The price of water is highly variable within every state, reflecting the very localized nature of water markets.
4. Using a 3% interest rate to annualize the prices of water rights and looking across the West as a whole, the median price of water rights is almost twice that for leases.
5. Across the western states, the median price of water is highly variable, with Colorado and Nevada having the highest medians when sales of leases and rights are combined. The median price of leases is greatest in Arizona, California, Kansas, and New Mexico. The median price of water rights is greatest in Colorado and Nevada.
6. Purchases for the purpose of mining garner the highest median price, but the number of sales (all leases) is small. Purchases for municipal uses have the next highest median price (\$88) and account for over half of all sales. Sales for agricultural irrigation, environmental protection, and recreation have lower median prices (roughly \$35).
7. Purchases for municipal purposes have tended to be of water rights, whereas purchases for irrigation, environmental, recreational, thermoelectric, or mining purposes have tended to be of leases.
8. Median prices for municipal, irrigation, and environmental purposes all vary considerably across the states. For municipal purposes the highest medians (above \$100) are for California, Colorado, and Nevada and the lowest medians (below \$30) are for Texas and Utah. For irrigation purposes the highest median

(\$79) is for Colorado and the lowest medians (at or below \$10) are for Idaho, Oregon, Utah and Wyoming. For environmental purposes the highest median (\$60) is for California and the lowest medians (below \$15) are for Colorado and Idaho. Note that because some of the sample sizes are small, these state-wide medians may have been heavily affected by characteristics of the water markets where these transactions occurred, and therefore may not give an accurate picture of the relative values across the states.

9. Farmers are the sellers in nearly half of the transactions. Public agencies, such as federal agencies managing large water storage and delivery projects, are the sellers in another 15% or so of the transactions. Municipalities are the most common buyers, accounting for about 30% of the transactions. Other common buyers are farmers, public agencies, and water districts.
10. Across all cases, the median price of leases in real terms shows no consistent trend over the past 13 years, whereas the median price of water rights shows an upward trend. The median price of water purchased for municipal purposes shows no trend, but the median price of water purchased for irrigation has tended to decrease. The number of purchases for environmental purposes has been increasing, whereas the number for irrigation has been decreasing.
11. The number of leases has been growing, whereas the number of sales of water rights shows no trend.
12. Water market prices tend to over-estimate the marginal value of streamflow because water market prices include return for the value of storage and conveyance of the water.

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Table 1. Western water market prices by state, 1990-2002 (both leases and rights, 2002 dollars per acre-foot per year*)

	Mean (\$)	Median (\$)	N	Min (\$)#	Max (\$)
Arizona	61	51	82	1	424
California	99	67	249	1	614
Colorado	135	94	398	1	642
Idaho	14	7	61	0	245
Kansas	39	47	15	13	53
Montana	22	5	5	2	55
New Mexico	76	54	55	1	593
Nevada	118	103	60	7	340
Oklahoma	241	116	3	45	563
Oregon	31	9	39	1	295
Texas	101	27	190	7	2207
Utah	43	16	40	5	426
Washington	70	31	23	11	365
Wyoming	37	40	32	3	91
All	97	59	1252	0	2207

* Water rights prices were annualized using a 3% interest rate.

Cases with a \$0 price were not included. \$0 indicates rounding of a very low price.

Table 2. Western water market prices by type of transaction, 1990-2002 (2002 dollars per acre-foot per year)

	Mean (\$)	Median (\$)	N	Min (\$)#	Max (\$)
Lease	84	45	640	0	2207
Right*	111	83	612	1	642
All	97	59	1252	0	2207

* Annualized using a 3% interest rate.

Cases with a \$0 price were not included. \$0 indicates rounding of a very low price.

Table 3. Western water market prices by state and type of transaction, 1990-2002 (2002 dollars per acre-foot per year)

	Leases		Rights*	
	Median (\$)	N	Median (\$)	N
Arizona	58	51	47	31
California	75	211	40	38
Colorado	13	51	99	347
Idaho	7	46	7	15
Kansas	49	10	15	5
Montana	5	5		0
New Mexico	54	26	74	29
Nevada	81	4	105	56
Oklahoma	339	2	45	1
Oregon	9	30	7	9
Texas	29	144	24	46
Utah	10	10	23	30
Washington	35	20	14	3
Wyoming	40	30	43	2
All	45	640	83	612

* Annualized using a 3% interest rate.

Table 4. Western water market prices by purpose of buyer, 1990-2002 (both leases and rights, 2002 dollars per acre-foot per year)

Purpose	Mean (\$)	Median (\$)	N	Min (\$)#	Max (\$)
Municipal	119	88	665	1	762
Irrigation	50	30	304	1	486
Environment	48	37	128	0	305
Thermoelectric	62	18	8	1	335
Recreation	49	33	8	10	152
Mining	426	172	26	47	2207
Recharge	48	55	5	31	59
Other	104	57	55	2	593
Several	55	55	53	3	185
All	97	59	1252	0	2207

* Water rights prices were annualized using a 3% interest rate.

Cases with a \$0 price were not included. \$0 indicates rounding of a very low price.

Table 5. Western water market prices by purpose of buyer and type of transaction, 1990-2002 (2002 dollars per acre-foot per year)

Purpose	Leases		Rights*	
	Median (\$)	N	Median (\$)	N
Municipal	74	251	96	414
Irrigation	16	183	77	121
Environment	42	99	29	29
Thermoelectric	11	7	43	1
Recreation	27	6	119	2
Mining	172	26		0
Recharge	37	3	57	2
Other	57	24	62	31
Several	54	41	61	12
All	45	640	83	612

* Water rights prices were annualized using a 3% interest rate.

Table 6. Western water market prices by state and purpose of buyer, 1990-2002 (both leases and rights, 2002 dollars per acre-foot per year)

	Municipal		Irrigation		Environmental	
	Median (\$)	N	Median (\$)	N	Median (\$)	N
Arizona	53	41	44	14	46	6
California	112	128	48	57	60	44
Colorado	107	230	79	109	13	11
Idaho	8	5	7	29	8	19
Kansas	47	13	50	2		0
Montana		0	5	1	2	3
New Mexico	74	25	23	5	44	6
Nevada	107	51		0	36	6
Oklahoma	116	3		0		0
Oregon		0	9	17	21	18
Texas	26	129	25	37		0
Utah	20	25	10	13	56	2
Washington	48	3	16	5	31	13
Wyoming	78	12	5	15		0
All	88	665	30	304	37	128

* Water rights prices were annualized using a 3% interest rate.

Table 7. Western water market prices by type of buyer and seller, 1990-2002 (both leases and rights, 2002 dollars per acre-foot per year)*

Type	Seller		Buyer	
	Median (\$)	N	Median (\$)	N
Municipality	54	69	68	350
Farmer	73	502	27	197
Environmental entity	65	2	19	15
Water district	47	120	68	156
Public agency	42	194	49	206
Power company	99	5	34	10
Mining company	590	2	172	26
Developer	107	24	113	24
Other	74	137	57	85
Several	65	197	89	183
All	59	1252	59	1252

* Water rights prices were annualized using a 3% interest rate.

Table 8. Number of Western water market trades from seller to buyer, 1990-2002 (includes both leases and rights)

Seller	Buyer									
	Munic	Farmer	Envir	District	Public	Power	Mining	Devel	Other	Several
Municipality	26	9	0	7	15	0	0	0	8	4
Farmer	164	95	11	48	91	3	6	9	21	54
Environmental	1	0	1	0	0	0	0	0	0	0
Water district	20	19	1	33	24	1	0	1	6	15
Public agency	34	42	1	28	36	2	3	0	13	35
Power plant	3	0	0	0	1	0	0	1	0	0
Mining	1	0	0	0	0	0	1	0	0	0
Developer	15	0	0	2	6	0	0	0	1	0
Other	36	12	1	20	14	2	1	13	35	3
Several	50	20	0	18	19	2	15	0	1	72

Table 9. Number of Western water market trades by purpose of buyer, 1990-2002 (includes both leases and rights)

Buyer	Purpose								
	Munic.	Irrig.	Envir.	Elect.	Recre.	Mining	Recha.	Other	Several
Municipality	334	6	5	0	2	0	0	0	3
Farmer	1	191	0	0	0	0	1	2	2
Environmental	0	0	15	0	0	0	0	0	0
District	96	53	0	0	0	0	1	2	4
Public agency	41	15	103	0	5	0	1	25	16
Power plant	2	0	1	7	0	0	0	0	0
Mining	0	0	0	0	0	25	0	0	1
Developer	22	1	0	0	0	0	0	1	0
Other	39	16	2	0	1	0	1	25	1
Several	130	22	2	1	0	1	1	0	26

Table 10. Volume of water purchased via leases by purpose of buyer, 1990-2002 (acre-feet per year)

Buyer	Purpose									Total
	Munic.	Irrig.	Envir.	Elect.	Recre.	Mining	Recha.	Other	Several	
Municipality	139895	654	0	0	471	0	0	0	65	141085
Farmer	0	238419	0	0	0	0	231	23	1531	240205
Environmental	0	0	1054	0	0	0	0	0	0	1054
District	80851	73565	0	0	0	0	2308	231	1553	158508
Public agency	41446	14133	246844	0	2252	0	0	18240	124054	446969
Power plant	1139	0	1231	39997	0	0	0	0	0	42367
Mining	0	0	0	0	0	3108	0	0	132	3239
Developer	0	0	0	0	0	0	0	0	0	0
Other	3826	18612	11462	0	31	0	6891	7242	10	48073
Several	99475	40401	3110	2643	0	0	0	0	427109	572738
Total	366633	385784	263700	42640	2754	3108	9429	25735	554454	1654238

Table 11. Volume of water purchased via water rights by purpose of buyer, 1990-2002 (acre-feet per year)

Buyer	Purpose									Total
	Munic.	Irrig.	Envir.	Elect.	Recre.	Mining	Recha.	Other	Several	
Municipality	21446	48	73	0	0	0	0	0	385	21952
Farmer	13	2659	0	0	0	0	0	12	0	2684
Environmental	0	0	847	0	0	0	0	0	0	847
District	9419	523	0	0	0	0	0	0	0	9942
Public agency	18611	2729	7649	0	142	0	1202	1539	361	32234
Power plant	0	0	0	498	0	0	0	0	0	498
Mining	0	0	0	0	0	0	0	0	0	0
Developer	464	5	0	0	0	0	0	0	0	470
Other	2338	197	0	0	0	0	0	113	0	2648
Several	3736	492	0	0	0	0	1	0	5389	9618
Total	56027	6654	8569	498	142	0	1203	1665	6135	80893

Figure 1. Number of cases meeting criteria for analysis of market prices, 1990-2002, by climatic division (divisions are numbered independently within each state)

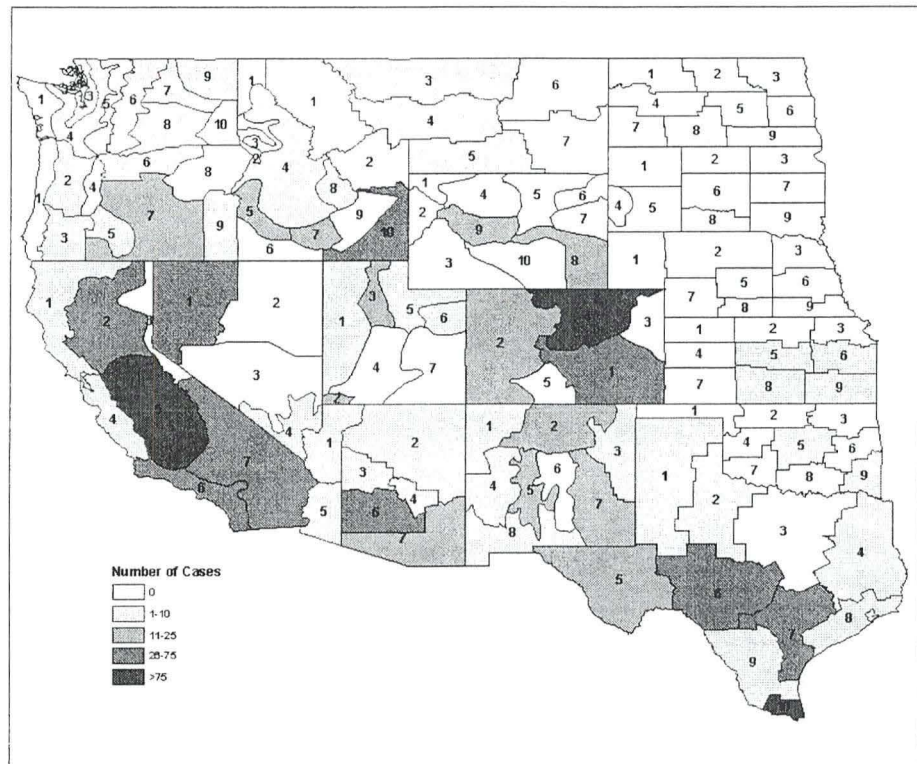


Figure 2. Trends in total number of acre-feet transferred

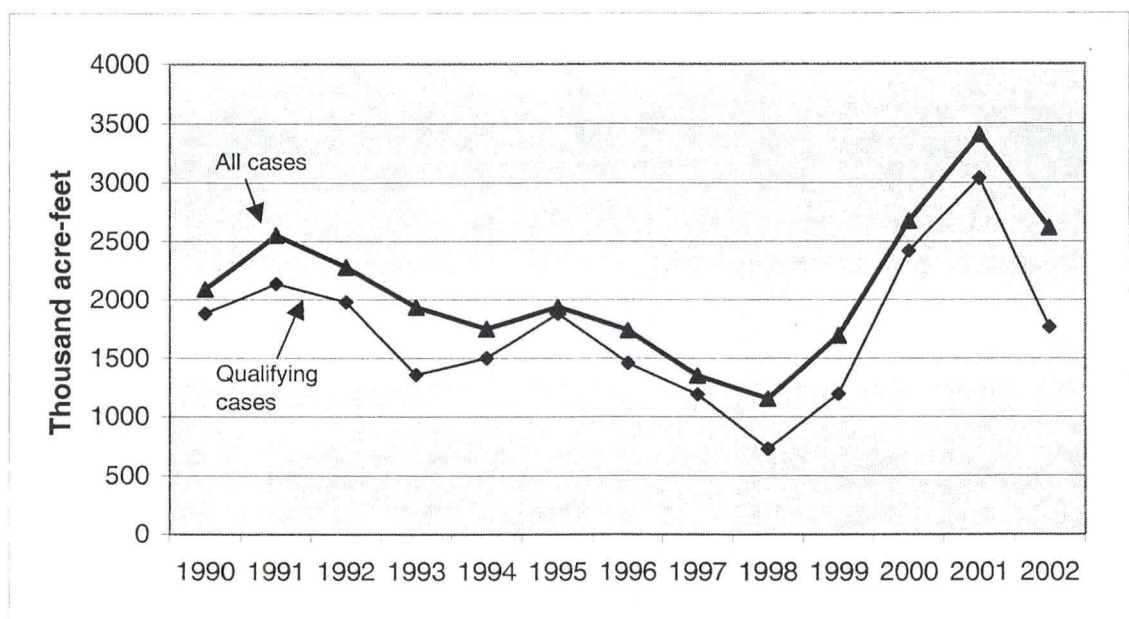


Figure 3. Trends in total quantity of water transferred (qualifying cases only)

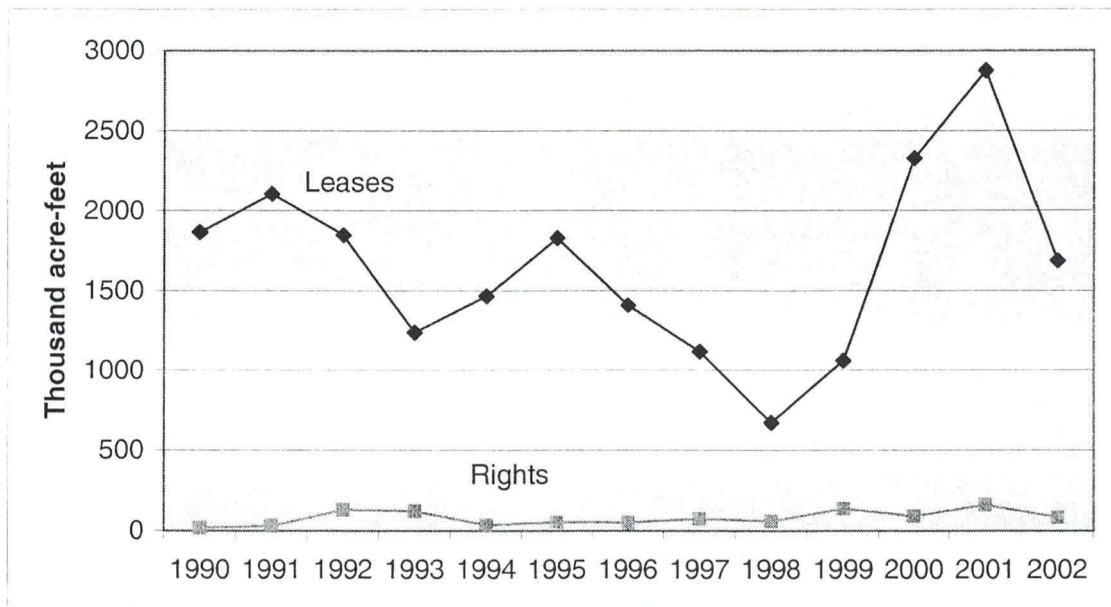


Figure 4. Distribution of prices paid for water, all water uses, 1990-2002 (including both leases and rights, year 2002 dollars)

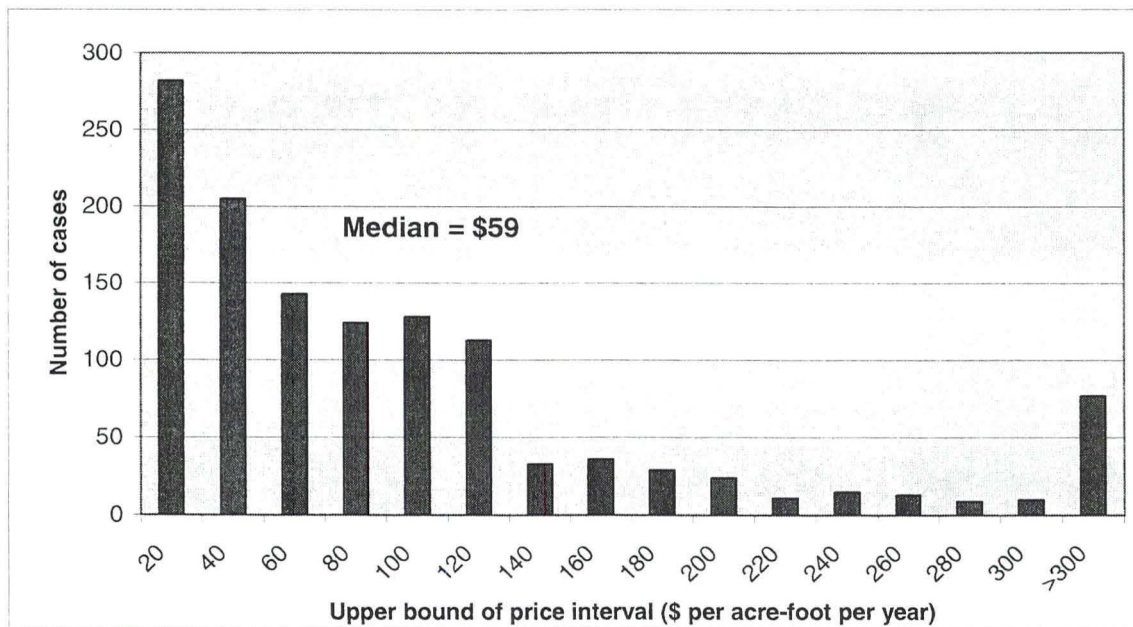


Figure 5. Distribution of prices paid for water for municipal purposes, 1990-2002 (including both leases and rights, year 2002 dollars)

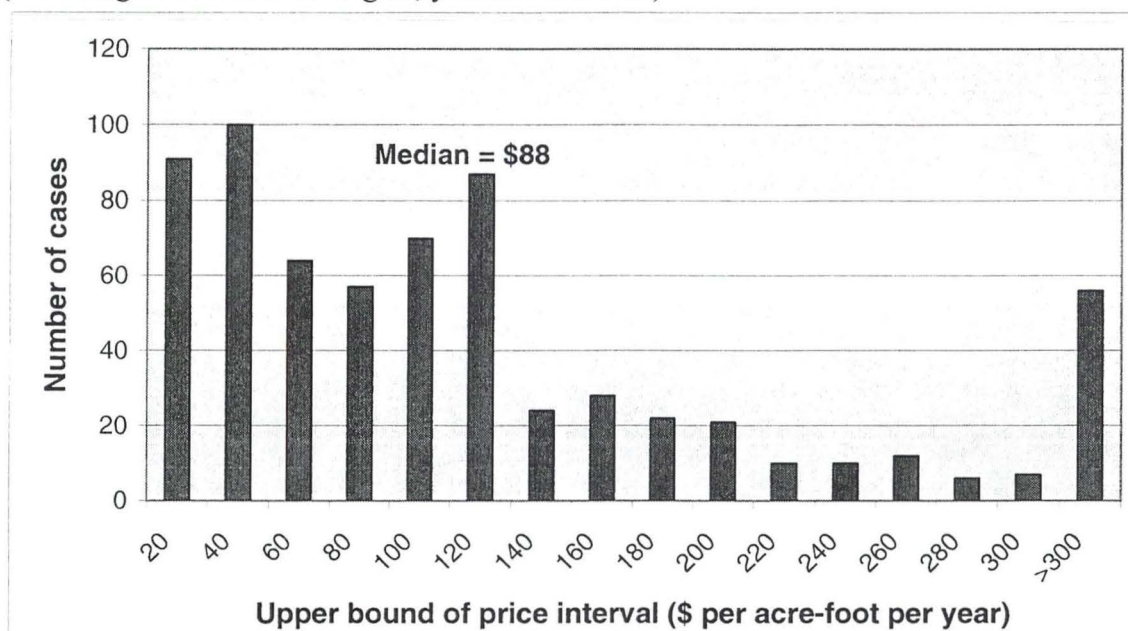


Figure 6. Distribution of prices paid for irrigation water, 1990-2002 (including both leases and rights, year 2002 dollars)

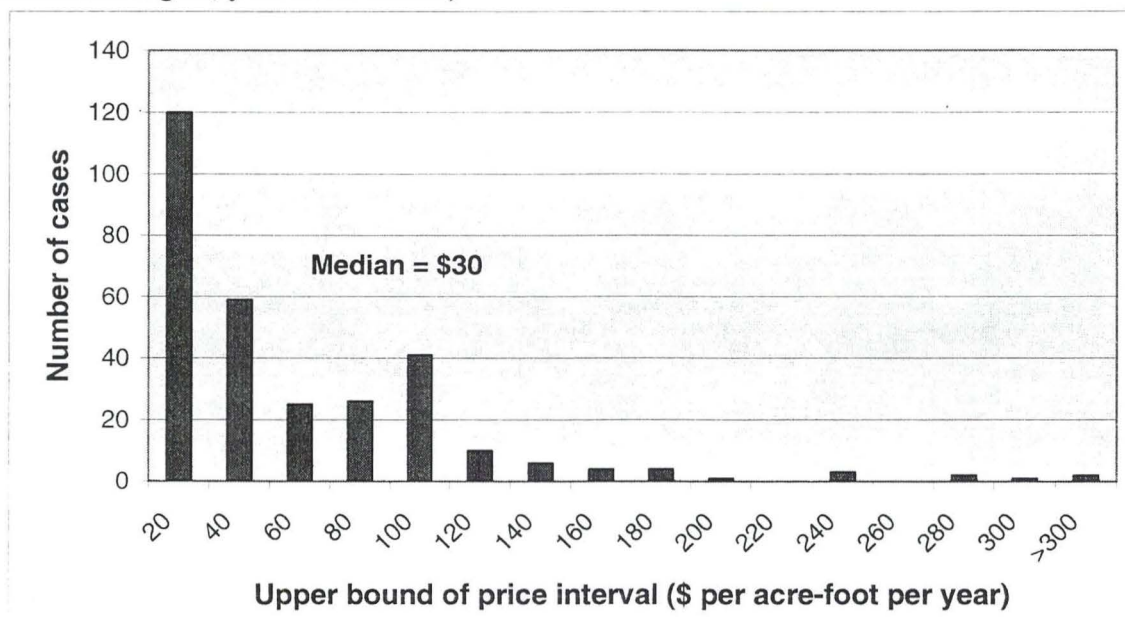


Figure 7. Distribution of prices paid for water for environmental purposes, 1990-2002 (including both leases and rights, year 2002 dollars)

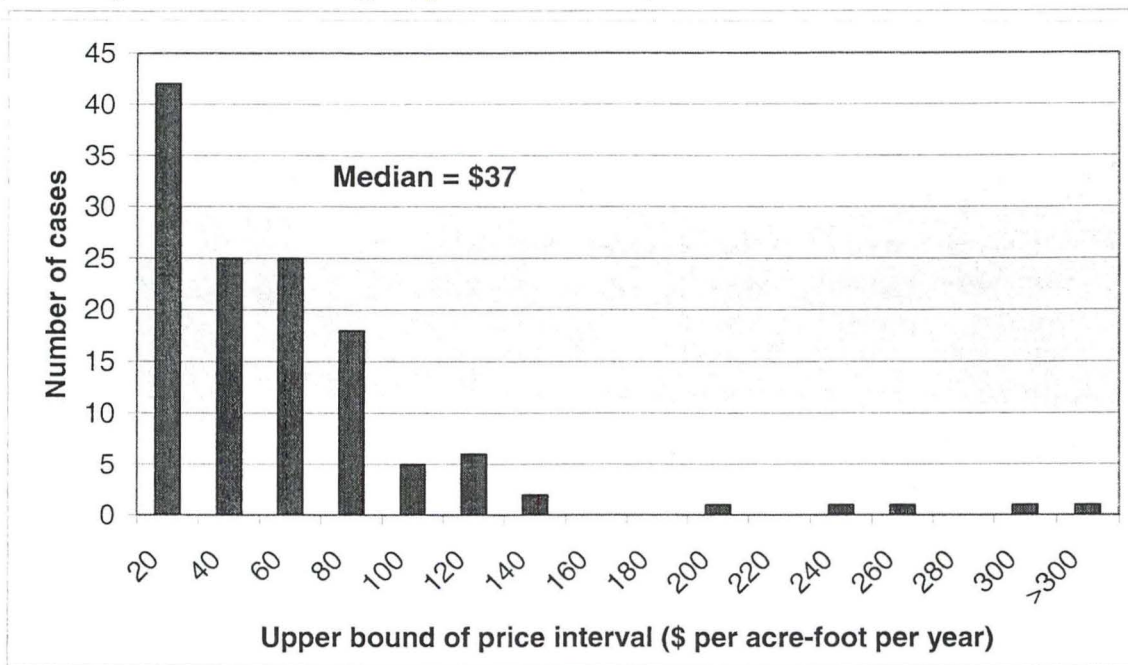


Figure 8. Trend in median price of water, all water uses (includes both leases and rights, year 2002 dollars)

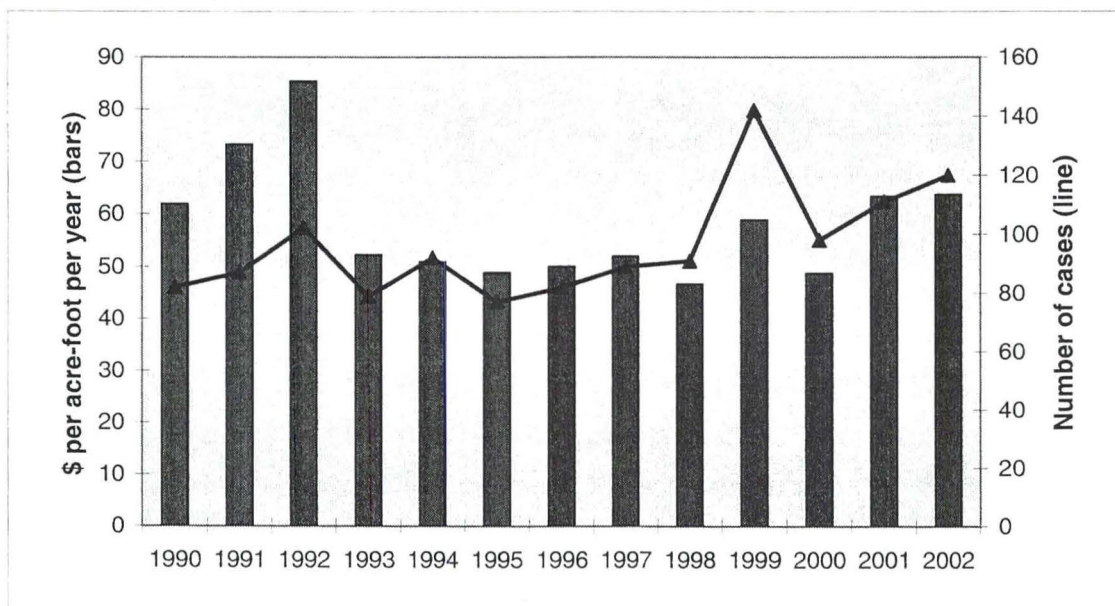


Figure 9. Trends in number of cases by type of transaction, all water uses, 1990-2002

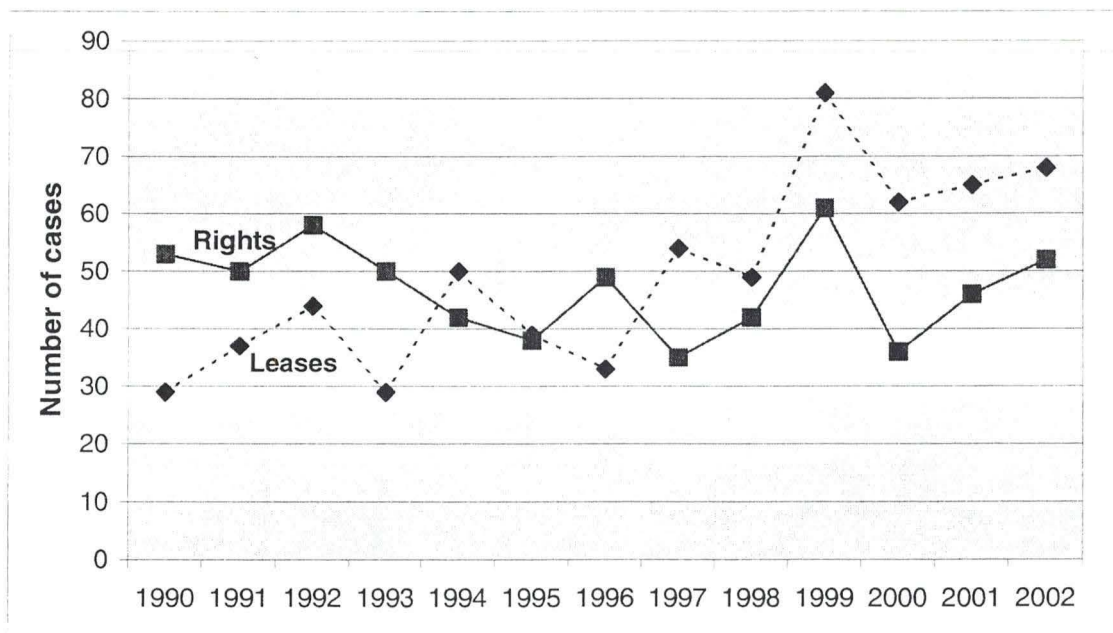


Figure 10. Trends in median water price by type of transaction, all water uses (year 2002 dollars)

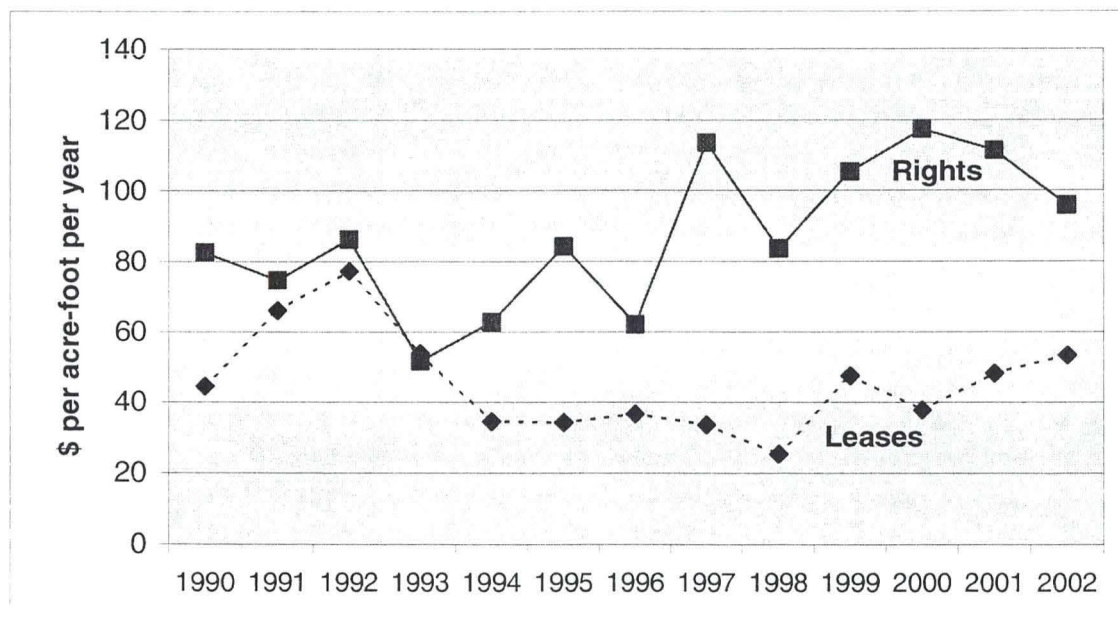


Figure 11. Trends in median price of water rights for three states, all water uses (year 2002 dollars)

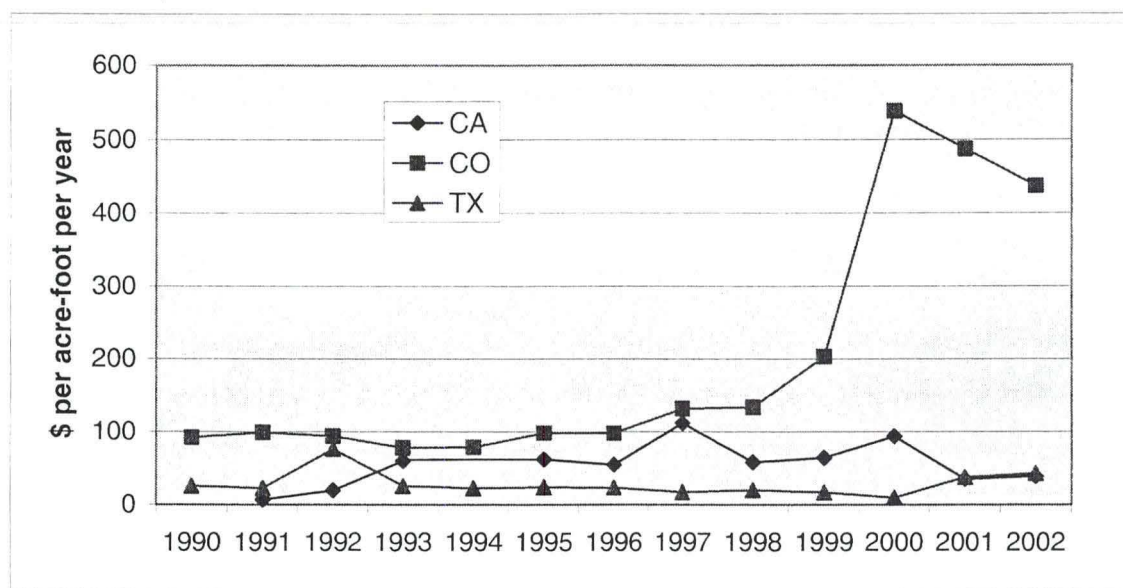


Figure 12. Trend in median price of water purchased for municipal purposes (includes both leases and rights, year 2002 dollars)

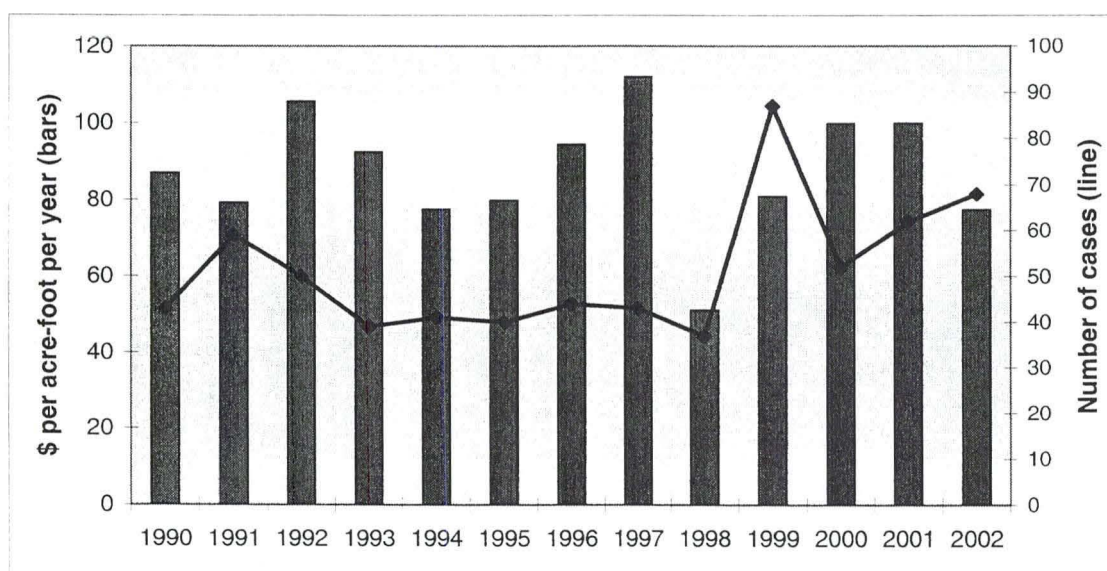


Figure 13. Trend in median price of water purchased for irrigation use (includes both leases and rights, year 2002 dollars)

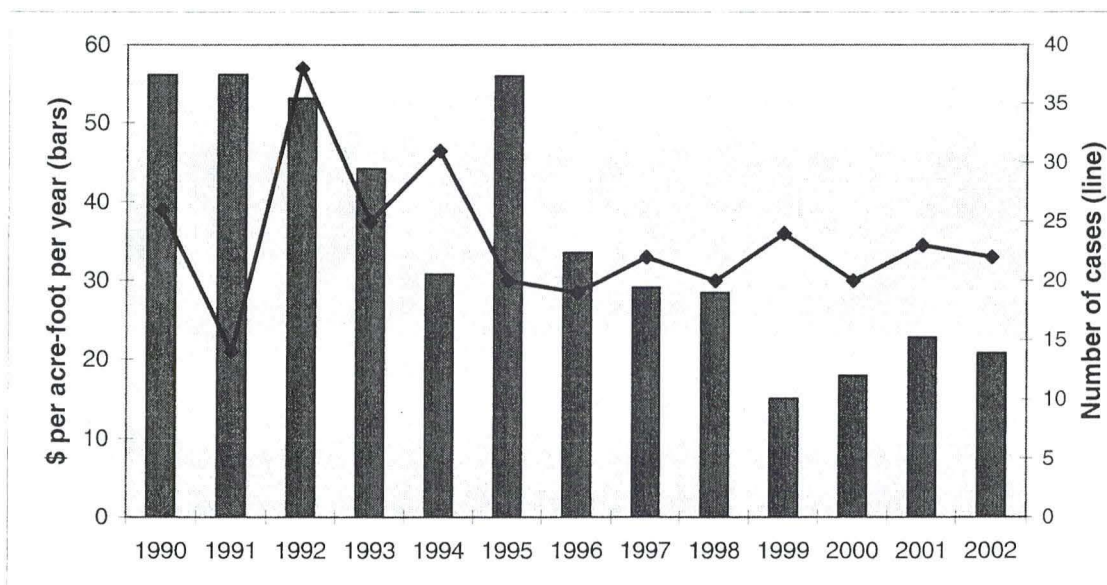


Figure 14. Trend in median price of water purchased for environmental purposes (includes both leases and rights, year 2002 dollars)

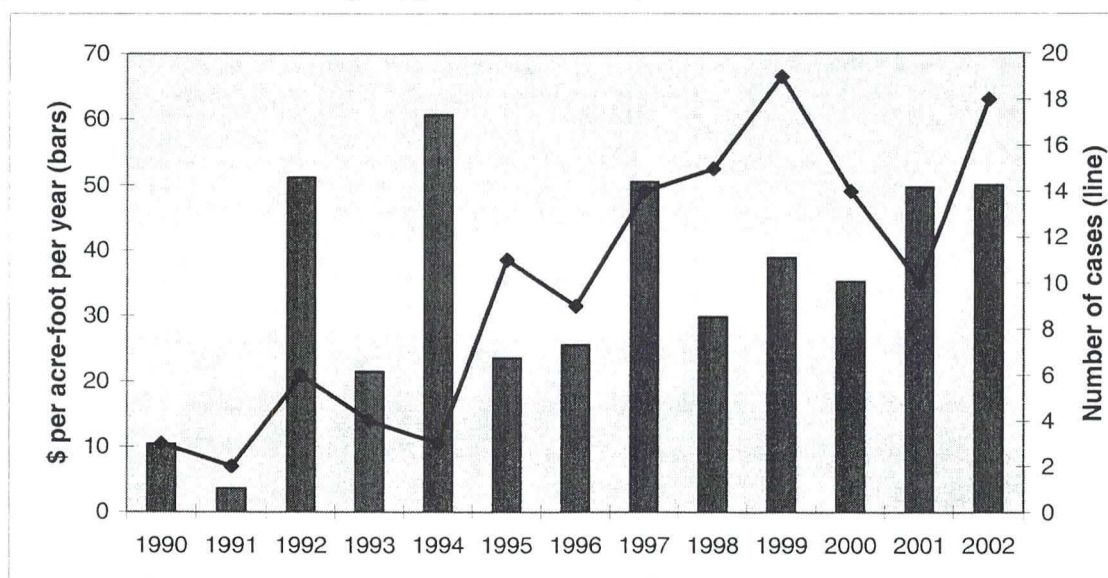


Figure 15. Trends in median price of water rights in selected Colorado markets (year 2002 dollars)

